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THE VIRGINIA JOURNAL OF SCIENCE

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Inhibition of *in vitro* Heme Synthesis from N^{15}-Glycine by 2,5-Dimethylbenzimidazole, 5,6-Dimethylbenzimidazole and Related Compounds[1]

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5,6-Dimethylbenzimidazole is a part of the vitamin B_{12} molecule. Emerson and associates (1950) studied the vitamin B_{12}-like activity of this and related compounds when fed to rats on diets devoid of animal protein and containing thyroid powder. They noted that, unlike 5,6-dimethylbenzimidazole which had vitamin B_{12}-like growth activity, 2,5-dimethylbenzimidazole appeared to act as a growth depressant. This property was not exhibited by benzimidazole itself or by any of the other mono- or dimethylbenzimidazoles studied. They remarked that 2,5-dimethylbenzimidazole might have "inhibitor activity". Because of the chemical relationship of 2,5-dimethylbenzimidazole to the benzimidazole moiety of vitamin B_{12} and to the purines, we have investigated its effect on the *in vitro* synthesis of heme by chicken erythrocytes.

The present studies indicate that 2,5-dimethylbenzimidazole is a potent inhibitor of the utilization of glycine for heme synthesis in chicken erythrocytes incubated *in vitro*. Investigation of related compounds indicated that benzimidazole, the 2-methyl- and the 5-methylbenzimidazole had some, but not comparable, inhibitory effects in this system. Since the 5-methyl derivative appeared to be somewhat more effective, 5,6-dimethylbenzimidazole was investigated and found to be equally as effective as 2,5-dimethylbenzimidazole. 2-Ethyl-5-methylbenzimidazole was found to be the most effective inhibitor of all. The chemical relationship of these compounds to each other, and to vitamin B_{12} and the purines, is illustrated in Figure 1.

EXPERIMENTAL

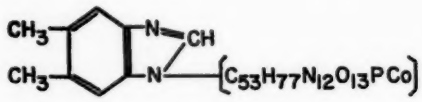
The nucleated erythrocytes of avian blood have been shown to incorporate N^{15} from labeled glycine into the protoporphyrin of hemoglobin which

[1] Presented at the 32nd annual meeting of the Virginia Academy of Science, Charlottesville, May 7, 1954. This paper was awarded the J. Shelton Horsley Research Award for 1954 and appears at the request of the Editors of the Virginia Journal of Science. Studies with the methyl-substituted benzimidazoles were published in the Journal of Biological Chemistry [211 (845), December, 1954], and those with 2-ethyl-5-methylbenzimidazole appeared in the Proceedings of the Society for Experimental Biology and Medicine [86 (475), July, 1954].

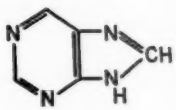
* Paper received November 15, 1954.

can be isolated as N^{15}-labeled hemin after incubation of duck blood with N^{15}-glycine (Shemin et al., 1948, 1950).

In the present experiments we have used chicken blood in this way as an *in vitro* biological test system for the study of hemoglobin synthesis. Twenty ml. blood samples were incubated with the experimental compound and 25 mg. glycine containing 31 atom per cent N^{15} (Schoenheimer et al., 1939) in 50 ml. Erlenmeyer flasks with constant shaking for 24 hours in a water bath at 37° C. In each experiment the effect on heme synthesis of the substance studied was determined by comparison with a control sample of the same blood incubated with N^{15}-glycine only at the same time under identical conditions. Hemin was isolated as described by Shemin and Rittenberg (1946) and recrystallized according to Fischer (1941). Hemin from each blood sample was analyzed for N^{15} content in a mass spectrometer. Each of duplicate samples was compared with tank nitrogen as a reference standard and the N^{15} atom per cent excess over tank nitrogen determined.



VITAMIN B_{12}



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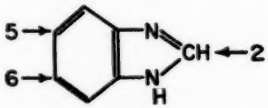

BENZIMIDAZOLE

2-METHYL—
5-METHYL—
2,5-DIMETHYL—
5,6-DIMETHYL—
2-ETHYL-5-METHYL—

FIGURE I.—Benzimidazole derivatives studied and their relationship to the vitamin B_{12} and purine structures.

RESULTS

In our previous studies it was determined that the N^{15} concentration of isolated hemin was the same in the test and control samples if a supple-

mentary compound did not affect the incorporation of N^{15} from N^{15}-glycine into heme (Abbott et al., 1952). In the present experiments, however, a progressive decrease in hemin N^{15} content was noted with increasing amounts of 2,5-dimethylbenzimidazole (Table I). In the presence of 10 mg. (.003M) 2,5-dimethylbenzimidazole (Exps. 2,3,4) the incorporation of N^{15} was decreased considerably, whereas with 15 mg. (.005M) blocking of isotope incorporation was almost complete (Exps. 5,6). Inhibition was slight with 5 mg. (Exp. 1) but complete with 20 mg. (Exps. 7,8). Addition of vitamin B_{12}, either 15 μg. or 100 μg. (Exps. 3,5), or of 25 mg. folic acid (Exp. 6), did not alter the effect of 2,5-dimethylbenzimidazole; the N^{15} content of the hemin was the same as with 2,5-dimethylbenzimidazole alone. In Exp. 7 complete inhibition by 20 mg. 2,5-dimethylbenzimidazole was compared with the lesser effect of 20 mg. adenine. Exps. 9, 12 and 15 show that 15 mg. benzimidazole had some inhibitory effect which was not comparable to that obtained with the same amount of the 2,5-dimethyl derivative. The lesser effect of 20 mg. of benzimidazole compared with 20 mg. of the 2,5-dimethyl derivative is seen in Exp. 8. Similarly, 2-methylbenzimidazole (Exps. 10, 11 and 12) had a slight effect which was comparable to that of benzimidazole (Exp. 12). That this effect was real however, is indicated in Exp. 11 in which an additional flask incubated with 15 mg. orotic acid showed no difference from the control sample. The 5-methyl derivative (Exp. 13) had a greater effect than either benzimidazole or the 2-methyl derivative (Exp. 12) although not so great as that with the same amount of 2,5-dimethylbenzimidazole (Exps. 5,6). This suggested the importance of the 5 position and 5,6-dimethylbenzimidazole was obtained from Dr. Karl Folkers and studied. It was found to be equally as effective as 2,5-dimethylbenzimidazole in blocking incorporation of isotope into heme (Exps. 14-17). Inhibition was almost complete with 15 mg. and complete with 20 mg. (Exps. 16,17). The formic acid salt of 5,6-dimethylbenzimidazole and the free base were both inhibitory (Exps. 14-17).

Experiments 18-21 show that 2-ethyl-5-methylbenzimidazole was considerably more inhibitory than 2,5-dimethylbenzimidazole. Thus 5 mg. (.0017M), which produced minimal (18%) inhibition with 2,5-dimethylbenzimidazole, gave marked (67%) inhibition with the 2-ethyl-5-methyl derivative (Exp. 18). Ten mg. 2-ethyl-5-methylbenzimidazole (.003 M) gave complete inhibition whereas this required 20 mg. 2,5-dimethylbenzimidazole (Exps. 19 and 20). Two mg. 2-ethyl-5-methylbenzimidazole (.0006 M) produced approximately the same degree of inhibition as 20 mg. benzimidazole (.0085 M). Thus 2-ethyl-5-methylbenzimidazole was as effective as 14 times the concentration of benzimidazole, and at the .0016 M level the percentage decrease in N^{15} uptake from the control experiment was about 4 times greater with the 2-ethyl-5-methyl derivative than with 2,5-dimethylbenzimidazole. Complete inhibition occurred with half the amount required by 2,5-dimethylbenzimidazole.

DISCUSSION

It is apparent that 2,5-dimethylbenzimidazole, 5,6-dimethylbenzimidazole, and 2-ethyl-5-methylbenzimidazole prevent the incorporation of N^{15} from N^{15}-glycine into heme by chicken erythrocytes when incubated *in vitro* as described. These were more effective than adenine and at concentrations much lower than we found previously with sodium fluoride (Abbott et al., 1952). A slight, but not comparable, effect was exhibited by benzimidazole and the 2-methyl derivative, and 5-methylbenzimidazole had an effect intermediate between that of benzimidazole and 2,5-dimethylbenzimidazole. Substitution of a methyl group in the 5 position apparently increased the inhibitory effect of benzimidazole; this was enhanced markedly by further methyl substitution in the 2 or 6 positions, and to an even greater extent by substituiton of an ethyl group in the 2 position.

The mechanism whereby these compounds interfere with the introduction of N^{15} from glycine into heme during *in vitro* incubation of chicken erythrocytes is not known. In previous studies we found inhibition to occur with certain enzyme inhibitors such as fluoride (Abbott et al., 1952) and dinitrophenol. 5,6-Dimethylbenzimidazole is a part of the vitamin B_{12} molecule and is related structurally to part of the riboflavin molecule. It has been found to possess inhibitory properties for the vitamin B_{12}-requiring organisms *Lactobacillus lactis* Dorner, *Lactobacillus leichmannii,* and *Euglena gracilis* (Hendlin et al., 1951).

Benzimidazole itself has been found to be a purine (Woolley, 1944) and nucleic acid (Klotz et al., 1948) antagonist, active in tissue cultures as a growth inhibitor of vaccinia (Thompson, 1947), psittacosis (Morgan, 1952) and poliomyelitis viruses (Brown, 1952). Recently Brown, et al. (1953) reported that benzimidazole prolonged the incubation period of infection and reduced mortality in experimental poliomyelitis in mice.

TABLE I.—EFFECT OF 2,5-DIMETHYLBENZIMIDAZOLE AND RELATED COMPOUNDS ON INCORPORATION OF N^{15} FROM N^{15}-GLYCINE INTO HEME BY ERYTHROCYTES OF CHICKEN BLOOD DURING *in vitro* INCUBATION

Experiment	N^{15} concentration in hemin *		Supplement †
	Control	Test	
	atom per cent excess		
1	.076	.066	5mg 2,5-dimethylbenzimidazole
2	.066	.028	10mg 2,5-dimethylbenzimidazole
3	.060	.035	10mg 2,5-dimethylbenzimidazole
		.036	10mg 2,5-dimethylbenzimidazole + 15μg vit. B_{12}
4	.066	.041	10mg 2,5-dimethylbenzimidazole
5	.071	.009	15mg 2,5-dimethylbenzimidazole
		.009	15mg 2,5-dimethylbenzimidazole + 100μg vit. B_{12}
6	.073	.017	15mg 2,5-dimethylbenzimidazole
		.017	15mg 2,5-dimethylbenzimidazole + 25mg folic acid

Experiment	N^{15} concentration in hemin * Control	Test	Supplement †
	atom per cent excess		
7	.066	.003	20mg 2,5-dimethylbenzimidazole
		.042	20mg adenine
8	.066	.004	20mg 2,5-dimethylbenzimidazole
		.045	20mg benzimidazole
9	.071	.062	15mg benzimidazole
10	.072	.060	15mg 2-methylbenzimidazole
11	.081	.066	15mg 2-methylbenzimidazole
		.080	15mg orotic acid
12	.075	.062	15mg 2-methylbenzimidazole
		.061	15mg benzimidazole
13	.074	.035	15mg 5-methylbenzimidazole
		.037	15mg 5-methylbenzimidazole
14	.080	.029	15mg 5,6-dimethylbenzimidazole ‡
		.032	15mg 2,5-dimethylbenzimidazole
15	.082	.018	15mg 5,6-dimethylbenzimidazole ‡
		.066	15mg benzimidazole
16	.063	.012	15mg 2,5-dimethylbenzimidazole
		.003	20mg 5,6-dimethylbenzimidazole
17	.071	.006	20mg 5,6-dimethylbenzimidazole
18	.066	.054	5mg 2,5-dimethylbenzimidazole
		.022	5mg 2-ethyl-5-methylbenzimidazole
19	.080	.034	10mg 2,5-dimethylbenzimidazole
		.003	10mg 2-ethyl-5-methylbenzimidazole
20	.081	.008	20mg 2,5-dimethylbenzimidazole
		.051	3mg 2-ethyl-5-methylbenzimidazole
21	.078	.046	2mg 2-ethyl-5-methylbenzimidazole
		.042	20mg benzimidazole

* Hemin isolated from chicken blood has slightly increased N^{15} concentration over tank nitrogen similar to that of hemin from normal dog and human blood (Abbott et al., 1953). Values on the order of .002 to .006 atom per cent excess thus indicate complete inhibition of N^{15} incorporation into heme.

† Benzimidazole, 2-methylbenzimidazole, 2,5-dimethylbenzimidazole and 2-ethyl-5-methylbenzimidazole were prepared by refluxing the appropriate diamine and acid according to the general procedure of Wagner and Millett (1944). The compounds were recrystallized several times, and melting points and nitrogen analyses were checked before use. 5-Methylbenzimidazole was recrystallized several times from the Eastman Kodak Company product. We are indebted to Dr. Karl Folkers of Merck and Co. for supplying 2,5-dimethylbenzimidazole for the initial experiments and for all of the 5,6-dimethylbenzimidazole used. Folic acid was kindly supplied by Lederle Laboratories through the courtesy of Dr. B. L. Hutchings. Other supplements were commercial products.

‡ As the formic acid salt (24 per cent formic acid).

The possibility that 2,5-dimethylbenzimidazole, 5,6-dimethylbenzimidazole and 2-ethyl-5-methylbenzimidazole might be acting as purine or nucleic acid antagonists in hemoglobin synthesis is particularly attractive. If this mechanism were involved, these substituted benzimidazoles might prove to be much more potent nucleic acid antagonists or antiviral agents than benzimidazole itself.

The important work of Tamm, Folkers, Shunk, Heyl, and Horsfall (1953) on the inhibition of influenza virus multiplication by alkyl derivatives of benzimidazole has been described recently by Horsfall in The Harvey Lectures (1954). Not only has 2,5-dimethylbenzimidazole been found to be a more potent agent than benzimidazole in inhibiting multiplication of influenza A or B virus, but the inhibitory activities of the methyl-substituted benzimidazoles for *in vitro* heme synthesis are precisely in the same relative order as was found for virus multiplication inhibition, i.e., 2-methylbenzimidazole was about the same as benzimidazole, and the 5-methyl derivative was intermediate between the 2-methyl and the 2,5-dimethylbenzimidazole. 5,6-Dimethylbenzimidazole also inhibited virus multiplication at lower concentrations than benzimidazole. 2-Ethyl-5-methylbenzimidazole was one of the most potent of all. It was considered to be approximately 7 times more effective than 2,5-dimethylbenzimidazole and 19 times more so than benzimidazole (Tamm et al., 1953).

The striking coincidence of the relative inhibitory activities of these alkyl-substituted benzimidazoles for two widely different systems, *in vitro* hemoglobin synthesis by avian erythrocytes and virus duplication, indicates to us that some very fundamental mechanism underlying both processes is involved. This might be the result of selective inhibition of a basic step in the mechanisms whereby nucleic acid (or nucleoprotein) plays some very important role in biosynthesis. It is of interest to note that the 5 (or 6) position of benzimidazole is analogous to the 2 position of the purines. Recent discovery of 2-methyladenine (Dion et al., 1954, and Brown et al., 1954) and 2-methylhypoxanthine (Brown et al., 1954) in biological material brings attention for the first time to the existence of analogous methyl-substituted purines in nature.

ACKNOWLEDGMENT

We are very much indebted to Dr. William T. Ham and the Biophysics Department for use of the mass spectrometer and to Mr. Hyman Rosen for preparation of the N^{15}-glycine used.

SUMMARY

2,5-Dimethylbenzimidazole, 5,6-dimethylbenzimidazole and 2-ethyl-5-methylbenzimidazole prevent incorporation of N^{15} from N^{15}-glycine into heme by chicken erythrocytes during *in vitro* incubation. Benzimidazole and 2-methylbenzimidazole had slight, but not comparable, inhibitory action. 5-Methylbenzimidazole had an inhibitory effect intermediate between that of benzimidazole and 2,5-dimethylbenzimidazole. 2-Ethyl-5-methylbenzimidazole was the most potent of all.

The striking coincidence of the relative inhibitory activities of the substituted benzimidazoles for two widely different systems, *in vitro* hemoglobin synthesis by avian erythrocytes and virus duplication, indicates to us that some very fundamental mechanism underlying both processes is involved. This might be the result of selective inhibition of a basic step in biosynthetic mechanisms in which nucleic acid (or nucleoprotein) plays some very important role.

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The Eggs of the Slimy Salamander in Isle of Wight County, Virginia.

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Reported here is a description of a group of eggs of the slimy salamander, *Plethodon glutinosus glutinosus* (Green), found on May 30, 1953, in the Carrsville area of Isle of Wight County. The literature contains only three descriptions of the nest of this subspecies. In 1929 Noble and Marshall reported on two nests found in Arkansas caves, and in 1940 Fowler described a nest found in a rotting stump in West Virginia. The Carrsville nest consisted of seven adherent eggs found in a depression in a damp pile of paper cement bags. The shifting of the bags during the collecting operation made it impossible to determine whether or not a female had been guarding the eggs immediately prior to their exposure. Five salamanders were also collected from the bag heap, and all were *P. g. glutinosus*. Four of the salamanders were adults, and one was a juvenile. Three of the adults were females, and two of these had fully gravid ovaries but no large ova in their oviducts (evidence that they had not been depositing eggs recently). The remaining adult female had "spent" ovaries, containing no large ova. This female was probably the source of the egg group.

The eggs were arranged in a compact cluster, and were loosely connected by the adherence of their outer envelopes. Their general proportions and the character of their envelopes approximated closely those of the diagrammatic *Plethodon glutinosus* egg illustrated in Bishop's report (1941). They did not bear any resemblance to the diagrammatic *Plethodon cinereus* egg in the same report, the only other salamander egg that in any probability might have been found in the same habitat. The eggs did not closely approximate those described by Noble and Marshall (loc. cit.) in that they did not appear to have been contained in a "common envelope". The vitelline membrane was closely adherent over a faintly yellowish deutoplasmic mass. A diffuse light pigmentation of melanophores darkened the animal pole. The envelopes surrounding the vitelline membrane were thin, and could not be distinctly separated in binocular microscopic examination due to a cloudiness resulting from inadequate preservation. The eggs were in the early gastrula stage at the time of collection, and were preserved in the field shortly after their discovery.

The probable relationship of an adult female specimen to the eggs was suggested by the presence of adequate space beside the eggs for an attending adult. It is well known that adult *Plethodon cinereus* remain

* Paper received July 1, 1954.

near egg groups, and it is likely that this behavior is also characteristic of *glutinosus*. It was not possible to determine whether or not the eggs were suspended from the top of the crevice prior to their being exposed in collecting. It is of interest to note that one of the egg masses reported by Noble and Marshall was suspended in a crevice, and the other was found lying on the bottom of a similar niche. This is more likely the result of poor adherence of their eggs than of variable behavior of the females during egg deposition.

The Carrsville eggs were smaller than those described by Noble and Marshall (loc. cit.) who report "an average egg" measures 5.5 mm. in diameter, inner envelope 6 mm., outer envelope 6.5 mm., and the "common envelope or outer sphere" (Piersol, 1915) is variable in thickness, bringing the total diameter of the egg and capsules to about 7.5 mm. An average egg in the Carrsville group had a yolk mass of 3.5 to 4.0 mm. diameter, and the maximum diameter including the envelopes ranged from 5.0 to 5.5 mm. The difference between the dimensions of these two series of eggs may reflect a zoogeographic factor, but it is not possible to ascribe much importance to this possibility in light of the paucity of data. Other factors affecting total egg dimensions include the amount of water absorption which has taken place prior to preservation, the amount of shrinkage after preservation, and variations in the dimensions of eggs produced by different specimens of the same species. There has never been any report on the range in dimensions of *Plethodon* eggs at the time of deposition.

The two gravid females in the habitat of the egg group had full ova complements. The larger specimen (snout-vent length: 62.5 mm.) had 19 large ova; the smaller (snout-vent length: 61.5 mm.) had 16. The snout-vent length of the female with "spent" ovaries was 56.8 mm.

Noble and Marshall (loc. cit.) found eggs in "cleavage stages" on August 17, 1928, in Sheridan Cave, Mountain Home, Arkansas. Fowler (1940) found eggs on June 3, 1938, in a wooded valley near Ice Mountain, Hampshire County, West Virginia. Pope and Pope (1949) report that the height of the breeding season in the vicinity of Mountain Lake, Giles County, Virginia is between July 27 and August 9. The authors believe that the finding of an egg group in late May in Tidewater Virginia is not incompatible with these data, and it is not strong evidence for an extended breeding season. Although Bishop (1941, 1943) believes that *Plethodon glutinosus* eggs are deposited in New York before May, or possibly during that month, his conclusion is based upon circumstantial evidence. No direct proof has been obtained that this species breeds that early in a northern state, and "it scarcely seems possible that this species would breed at one season in the lowlands of central and southern New York and at another in the high mountains of Virginia; in fact, one would expect coincidence of breeding seasons in these two areas" (Pope and Pope, loc. cit.). It would certainly be unusual if the breeding season in central New York approximated, or preceded that in the lowlands of the eastern Virginia coastal plain.

Noble and Marshall (loc. cit.) concluded on the basis of their two nests that in regions where no caves occur "the adults penetrate into the ground for some depth to deposit their eggs, and the young, in seeking the outer world, follow crevices such as those formed by ground-waters and make their exit (from their subterranean nursery) — near springs." This is possible but not supported by proof. Nests found by Fowler (loc. cit.) and the authors support the view that eggs are deposited in various secluded spots in the usual habitat of the species. All of the nesting sites described are characteristically troglodytic, whether the "cave" is a crevice in a true cave, a dark hollow in a rotting stump, or an artificial cavity in a pile of soggy cement bags.

The number of eggs in the Carrsville series is small. Pope and Pope (loc. cit.) found the mean for large ova in gravid females to be 23.4, and the range, 17 to 33. They report, "since a few large eggs are found in the spent females it is not surprising that the dissected females held more eggs than the nests. Even if all the large eggs were laid there would probably be some post-laying loss." It is not possible to determine whether the seven eggs near Carrsville comprised a full complement of one female, but the only female found in the habitat who had been depositing eggs recently had no large ova retained in her ovaries or oviducts.

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A Simplified Method For The Determination of Azo Dyes in Tissues, Urine and Feces [1]

J. D. SPAIN [2] AND C. C. CLAYTON

Department of Biochemistry, Medical College of Virginia, Richmond

The final criterion for carcinogenicity of azo dyes as related to chemical structure (Miller and Miller, 1948) or dietary variation (Griffin and Baumann, 1948; Kensler, 1947-48; Miller, 1947-48) is the tumor incidence. Some indication, however, of the effect of these variables may be ascertained in a shorter time by the degree of cirrhosis (Miller and Miller, 1948), liver riboflavin concentration (Griffin and Baumann, 1948; Miller, Miller, Kline, and Rusch, 1948) and/or liver protein-bound azo dyes (Miller and Miller, 1947; Miller, Miller, Sapp and Weber, 1949). The method of Miller and Miller (1947) for the determination of the protein-bound dyes involves a number of time-consuming procedures which limit its usefulness when large numbers of analyses are involved. Therefore a method was developed for the determination of total azo dyes in tissues which required a minimum of time and equipment.

REAGENTS

95 per cent ethanol

11 N KOH (Approx.) Equal weights of 85 per cent U.S.P. KOH and of water

Concentrated hydrochloric acid, C.P.

Acid-alcohol solution: 16 gm. KCl, 50 ml. of 95 per cent ethanol, 100 ml. of concentrated HCl, made up to 500 ml. with water. This 2.4 N HCl solution approximates that obtained by the acidification and dilution of the KOH digest (see below) and is useful in dilutions of the azo dyes for reading in the colorimeter.

Stannous chloride-acid solution: 60 gm. of stannous chloride dissolved and made up to 100 ml. with concentrated HCl.

PROCEDURE

Rats which had been fed 3′-methyl-4-dimethylaminoazobenzene (3′me-DAB) were sacrificed by decapitation and the livers removed and weighed. Three gm. samples were removed from the left lateral and median lobes, homogenized with an all-glass tissue grinder, and made to 25 ml. with distilled water. Samples of 5 ml. of the homogenate were placed

[1] From a portion of a thesis submitted in partial fulfillment of the requirements for the degree of Master of Science by J. D. Spain, and presented in part at the Annual Meeting of the Virginia Academy of Science, Charlottesville, May, 1954. Supported in part by a grant-in-aid from the American Cancer Society upon recommendation of the Committee on Growth of the National Research Council and by research grant C-1541 of the National Cancer Institute of the National Institutes of Health, Public Health Service.

[2] Present address: Department of Chemistry, Stanford University, California.

* Paper received September 29, 1954.

in 50 ml. Erlenmeyer flasks with 7 ml. of 95 per cent ethanol and 2 ml. of 11 N KOH. The contents were mixed, and then refluxed for 20 hours at 80° C. (ether extraction-type hotplate) using cold-finger condensers. This method of liberating the dye was similar to that of Miller and Miller (1947) and found by them and from our studies to be the most satisfactory.

The slightly cloudy, yellow digests were then cooled below 15° C. individually in an ice bath and acidified to the pink azo dye color with additions of concentrated HCl dropwise with continued cooling and swirling. The slightly acid solution was washed into a 50 ml. graduated cylinder and diluted to 40 ml. with distilled water. Ten ml. of concentrated HCl were added and the contents mixed by inversion. The cylinder of acidified digest was allowed to stand for about 10 minutes in an ice-water bath and then filtered through rapid paper (Munktell's No. 3). The fatty acids and other acid-insoluble materials were removed leaving a clear, non-turbid filtrate.

The concentration of dye in the filtrate was determined with the Evelyn colorimeter using a 515 filter, the galvanometer being set at 100 with the acid-alcohol solution. Each sample served as its own blank by being re-read following reduction of the azo dyes by the addition of one drop of stannous chloride solution to 20 ml. of the filtrate. The optical density of the azo dyes was found by subtracting the optical density of the blank (L values with the Evelyn colorimeter) from the optical density of the original filtrate. If this value were multiplied by 10^4, we obtained an arbitrary number representing the units of azo dye in the sample diluted as outlined. One microgram of 3′-me-DAB was equivalent to 50 units. The azo dye color in the acid filtrate solution used for colorimetric reading was stable at room temperature for over 24 hours. This procedure is a measure of the total azo dye in the liver.

Animals which did not receive the dye had a very slight amount of material in the acidified liver digest which lost color with the stannous chloride treatment. This we have called the "false dye" reading and amounted to only about 30 units in the aliquot of liver used. It was quite constant under the conditions employed and could be disregarded for most comparative studies. (Values reported were corrected for the false dye.) The apparent amount of false dye from the control animals was influenced by the normality of the acid solution used in the colorimetric measurements, becoming more intense as the solution became more acidic. At a normality of HCl between 2 and 3 the false dye correction was minimized and slight changes in normality had little effect.

The method was compared with that for bound dye of Miller and Miller (1947) which involves trichloroacetic acid (TCA) precipitation, alcohol extraction and KOH alcohol digestion of the protein, followed by ether extraction and colorimetric determination in acid after removal of the ether. The effect on the dye content of trichloroacetic acid and alcohol extraction of the protein was also determined using the simpler procedure described. Aliquots from a pooled homogenate from the livers

of two rats fed 3′-me-DAB for five weeks were used in these studies and results calculated to units of dye per gram of fresh weight of liver (Figure 1.).

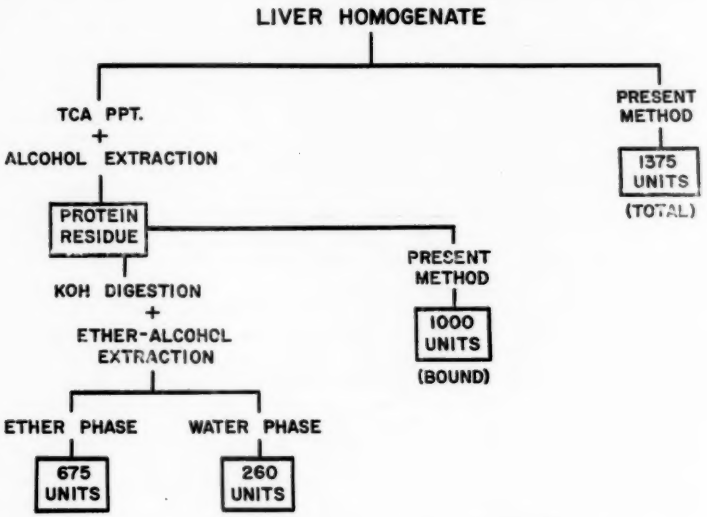

FIGURE 1.—Azo dye found in livers of rats fed 3′-methyl-4-dimethylaminoazobenzene for five weeks as measured by different procedures. (Units per gm. fresh weight).

When a sample of trichloroacetic acid (TCA) precipitated, alcohol washed protein (prepared according to Miller and Miller, 1947) was analysed by our procedure (5 ml. of water added to protein in digestion) it was found to contain 1000 units of the 1375 units of dye per gram originally present in the fresh homogenate. (Figure 1.). Approximately 25 per cent of the dye was extracted by alcohol and may be considered unbound or loosely bound.

Two ether extractions of the digest by the method of Miller and Miller (1947) did not remove all the dye from the alkaline solution, for when the aqueous residue was acidified and the color in this portion determined before and after reduction by stannous chloride it was found to contain 260 units. This amount plus the amount in the ether fractions accounted for 935 units which is comparable to the 1000 units found by the simpler procedure on the precipitated-alcohol extracted protein.

Modifications of the above procedure were found to work equally well with other tissues, urine, and feces. Urine and feces were collected in metabolism cages from rats which had been fed the dyes previously for

four weeks. The collection period was eight hours during which time the animals were given water but no food. This resulted in a collection that was not contaminated by diet. A measured amount of alcohol was added to the urine-collecting containers as a preservative. The urine was acidified to approximately 2.4 N with HCl, filtered, and diluted with the acid-alcohol solution for the colorimetric readings. Feces were macerated, allowed to stand for 20 hours in the acid-alcohol solution, then filtered, diluted, and the azo dye concentration determined.

ANIMAL EXPERIMENTS

Animals fed the dye, 3′-me-DAB, were killed at weekly intervals and the total liver azo dye determined. The amount of dye per gram of liver increased rapidly for the first three weeks to a level of 1800 units, after which there was a gradual, progressive decrease to the sixth week (when the experiment was terminated) when 1400 units of dye per gram of liver were found. This change in total liver azo dye concentration with time was similar to that found by Miller, Miller, Sapp, and Weber (1949) for their protein-bound dye. Routine determinations of rat livers in duplicate for azo dye resulted in a deviation from the mean of less than two per cent.

Less total azo dye was found in the liver after five weeks of dye feeding when the diet contained 5 μgm. of riboflavin per kilogram of diet than when it contained 1 μgm. of the vitamin. This is in line with the results of Miller and Miller (1947).

Azo dyes were also found in the urine and feces when 3'-me-DAB was fed. The amount in the urine varied between 1000 and 5000 units per rat per day while the feces were found to contain between 5000 and 10,000 units per day, based on an eight hour collection. The daily ingestion of the dye by the animals was approximately 320,000 units (10 gm. of 0.064 per cent 3′-me-DAB). Very little dye could be detected in the spleen or kidneys.

The method worked equally well for the determination of liver dye after feeding the less active carcinogen, 4-dimethylaminoazobenzene, although the amount per gram of liver was less. (cf. Miller, Miller, Sapp, and Weber 1949). No dye could be detected in the urine when this dye was fed.

DISCUSSION

With a simple rapid method for the determination of liver azo dye, it may be possible to ascertain more readily factors that affect the level of these compounds in the liver and the significance of these liver dyes and azo dye hepato-carcinogenesis. Present studies indicate the same trend in liver total azo dyes with respect to time and dietary variation as was found previously with protein-bound liver dyes. Should further investigation show that the bound liver dye is of more value than the total, a procedure of trichloroacetic acid (TCA) precipitation and alcohol extraction with the method as outlined would eliminate the processes of

drying, extraction, and solvent evaporation employed by Miller and Miller (1947). Such a procedure would give the total protein bound azo dye, whereas the use of organic solvent extraction removes and measures a portion of the dye.

Miller, Kline, Rusch, and Baumann (1944) and Spain (1953) have shown that various azo dyes have different distribution coefficients between chloroform and aqueous phases. From such distribution studies, Spain (1953) has evidence that the dyes present in the urine of rats fed 3'me-DAB are not the compound fed but are quite like those metabolites found in the livers of rats fed this compound. Furthermore, these solvent distribution studies and preliminary experiments with paper and column chromotography (unpublished) indicated that there were a number of dyes present in the liver and urine. Should such be the case, it may be that total or protein-bound dyes are not the main factors to be evaluated, but rather one or more definite dye metabolites and its, or their, influence on the carcinogenic process.

SUMMARY

A simple rapid method is described for the determination of total azo dye in tissues by alkaline digestion, acidification and filtration, and determination of color before and after reduction with stannous chloride. The method is compared with more time consuming methods now available. The method was also used for the determination of azo dyes in urine and feces.

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The Stereographic Projection of the Crystallographic Angles of *Beta*-tin * †

HENRY LEIDHEISER, JR.
Virginia Institute for Scientific Research

The determination of the orientation of metallic single crystals by X-ray back reflection analysis is a well-established technique. In order to carry out this technique it is necessary to know the angles between the important crystallographic planes. Such angles have been tabulated by Bozorth (1925) for the cubic metals and by Salkovitz (1951) for the hexagonal metals, magnesium, zinc, and cadmium. A table of the crystallographic angles of *beta*-tin has been published by Nicholas (1951) but the number of angles tabulated is generally insufficient to determine the orientation from the Laue back reflection photograph. Only 67 angles were given by Nicholas for planes making angles less than 60° with one another. A 60° angle is the maximum angle which can be determined from conventional back reflection X-ray photographs.

Using the equation for tetragonal metals,

$$\cos\phi = \frac{\dfrac{h_1h_2}{a^2}+\dfrac{k_1k_2}{a^2}+\dfrac{l_1l_2}{c^2}}{\sqrt{\left(\dfrac{h_1^2}{a^2}+\dfrac{k_1^2}{a^2}+\dfrac{l_1^2}{c^2}\right)\left(\dfrac{h_2^2}{a^2}+\dfrac{k_2^2}{a^2}+\dfrac{l_2^2}{c^2}\right)}},$$

where ϕ is the angle between the planes $(h_1\ k_1\ l_1)$ and $(h_2\ k_2\ l_2)$, and a and c are the lengths of the a and c axes, 310 angles were calculated between planes making angles less than 60° with one another. Values of $a = 5.831$ and $c = 3.182$ were taken from the work of Swanson and Tatge (1953). From the calculated angles the stereographic projection shown in Figure 1 was constructed. For most purposes angles can be taken from the stereographic projection with sufficient accuracy for orientation determination. It is useful, however, to have the angles in tabular form when in the process of identifying the Laue spots. Since these angles would consume too much space in the *Journal*, copies will be supplied to interested readers on request by the author, 326 N. Boulevard, Richmond 20.

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* These results were obtained during the course of a study sponsored by the American Can Company.

† *Beta*-tin, or white tin, is a member of space group D_{4h}^{19} (I4/amd), a body-centered lattice with 2 atoms in the unit cell. It transforms to the low-temperature *alpha* form, or gray tin, at approximately 13° C.

** Paper received February 1, 1955.

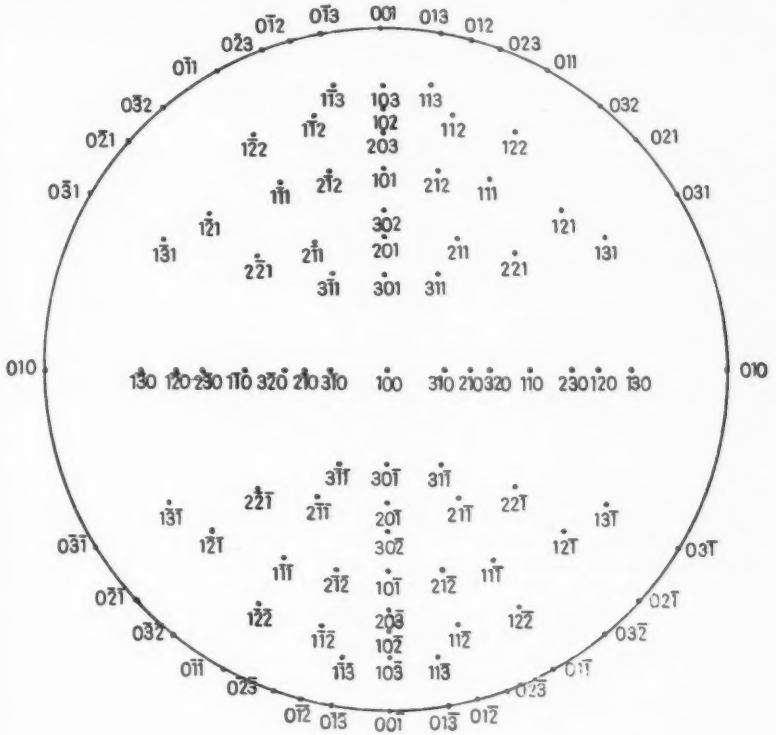

FIGURE 1.

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A Note on Spore Germination in *Psilotum nudum*

DAVID W. BIERHORST
University of Virginia

An unsuccessful attempt was made to germinate spores of *Psilotum nudum* (L.) Beauv. using the method described by Darnell-Smith (1918)[1], i.e., placing them between thin slabs of limestone in a fine layer of soil. Success was obtained, however, by mixing spores with Minnesota black soil and coarse sand, placing the mixture in an 8-inch clay pot, and planting a specimen of *Aspedistra* in the mixture. This was a duplication of the conditions under which mature gametophytes had been found growing. Periodically a soil sample was removed and examined for germinating spores.

The first indication of germination is the opening of the spore wall along the longitudinal slit, followed by the bulging of the spore contents out of the wall. This is followed by the first cell division which cuts off a relatively small cell at the apex of the bulge by an oblique wall. According to Darnell-Smith (1918), the first division occurs from 3 to 5 months after the spores are placed in an environment suitable for germination. Although spores were recovered at frequent intervals during the present study, the culture was 15 months old at the time of the first recovery of germinating spores. After the 15 month period, approximately 60 per cent of all the spores recovered were still alive, and of these approximately 50 per cent showed signs of germination. Of those that showed signs of germination, approximately 50 per cent were still in the one-celled stage and the remainder in the two-celled stage.

The subsequent stages, as described by Darnell-Smith, are characterized by cell divisions resulting in a tear-drop-shaped object very similar in appearance to a young plant of gemma-origin. Only one such plant was recovered during the present study, and this was 26 months after the spores were sown. Its total length was 0.5 mm., and it was easily distinguished from a plant of gemma-origin by the absence of a gemma or gemma scar. The spore wall was not attached.

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[1] Darnell-Smith, G. P. 1918. The gametophyte of *Psilotum*. Trans. Roy. Soc. Edin., 52: 79-91.

* Paper received January 25, 1955.

News and Notes

MINUTES OF THE COUNCIL MEETING, OCTOBER 31, 1954

The meeting of the Council of the Virginia Academy of Science was held at 2:00 P.M. in Mallory Hall, The Virginia Military Institute, Lexington, Virginia. Present were Lloyd C. Bird, Byron Cooper, President-elect Walter S. Flory, Jr., Allan T. Gwathmey, William M. Hinton, Horton H. Hobbs, Jr., Boyd Harshbarger, Edward S. Harlow, Sidney S. Negus, Paul M. Patterson, Foley F. Smith, and Stanley B. Williams. Also present, by invitation, were Emmert Ikenberry and A. M. Showalter, of Madison College, Harrisonburg; and Mrs. Thelma C. Heatwole, Chairman of the Junior Academy of Science Committee. President Irving G. Foster presided.

Minutes of the last Council meeting at the Annual May meeting were read and approved. Sidney Negus read the resumé of the life and career of Dr. E. C. L. Miller, late Secretary-Emeritus of the Academy, and then the resolutions adopted by the Council. On proper motion it was moved, seconded, and passed that this resumé and resolutions be made a permanent part of the minutes and archives of the Academy. The resolutions follow as part of these minutes, and were published separately in the January issue of the Virginia Journal of Science, Volume 6, New Series, No. 1, page 1.

The resolutions concerning the death of Justus Henry Cline prepared by Marcellus S. Stow, were also read, and it was moved, seconded, and passed that these resolutions be incorporated in the minutes of the Council, and that a copy be sent to Mrs. Cline. These resolutions (loc. cit., p. 56) were accepted by a rising vote of the members of the Council present.

Professors Showalter and Ikenberry were present to discuss the arrangements for the annual meeting of the Academy at Madison College, Harrisonburg, May 12-14.

The guest speaker for the May meeting was among the items discussed, and it was suggested that for this meeting we invite as speaker a distinguished meteorologist, instead of a physicist, and that the selection of the speaker be left in the hands of the President. It was suggested that Professors Ikenberry and Showalter also make arrangements to meet with Fred Young, Chairman of the Local Committee on Arrangements at the last annual meeting at the University of Virginia.

Future meeting places of the Academy were discussed, and an invitation to plan a joint meeting with the Tennessee Academy in Bristol was tabled at this time.

The Speakers' Bureau was next discussed, and it was decided to continue this Bureau for one more year for those who might wish to take advantage of the Bureau's facilities for furnishing authorities in scientific fields to speak before local groups.

Walter S. Flory next reported for the Committee to study the Virginia Science Talent Search. This rather full report was read to the Council, and the recommendations of this committee were approved and accepted.

Edward S. Harlow reported for the Long Range Planning Committee on Secondary Science Education. This meeting of the Committee was held in Richmond on October 2, 1954, and in addition to discussing the Science Education program, the Virginia Science Talent Search, the James River Basin Monograph, and the National Scientific Manpower problem were considered. This report was also approved and accepted. Copies of the report may be obtained from the Secretary, or from Mr. Edward S. Harlow, Chairman of the Committee.

It was moved, seconded and passed, that a committee be appointed to consider a request for funds to finance a study of State Science Search winners either from the National Science Foundation, or other such foundations.

It was suggested that a condensed version of the James River Basin be offered for sale at Jamestown Exposition, 1957. It was moved, seconded, and passed, that a Committee be appointed to confer with the Jamestown Exposition Commission, concerning any help that the Academy might offer in any capacity in which the facilities of the Academy might be used.

Boyd Harshbarger, Editor-in-Chief of the Journal, reported that a renewal of the printing contract, had been offered by Mr. Malcolm Donald Coe, Editor and Publisher of the Giles County Virginian, in Pearisburg. It was moved, seconded and passed that this bid be accepted for printing the Virginia Journal of Science for the next two years.

Dr. Harshbarger also suggested, and it was moved, seconded and passed, that Section 5, Paragraph 4, of the by-laws be changed to read: The staff shall be composed of: an Editor, an Associate Editor, and a Managing Editor instead of "an Editor-in-Chief, a Technical Editor, an Assistant Technical Editor——and the title Editor-in-Chief be changed to Editor wherever it might appear elsewhere in the by-laws and the other titles concerned above be changed respectively. Publications of this notice in the January issue of the Virginia Journal of Science will constitute official notice to the membership of the Academy; and this change will be voted on at the annual Academy Conference at Harrisonburg.

The Editorial Board of the Virginia Journal of Science was unanimously re-appointed and re-elected for another term, and received the official commendation of the Council for a job well done.

It was suggested that the committee on Place of Meeting for 1956 contact the Richmond Area University Center as a possible host to the Academy in planning a Richmond meeting in 1957.

The official thanks and appreciation were extended by the Council to Colonel and Mrs. I. G. Foster for their gracious hospitality to the Council, their wives, and guests at the very delightful buffet luncheon served at their home before the meeting.

There being no further business, the meeting adjourned at 4:15 P.M.

——FOLEY F. SMITH, *Secretary*

SECTION NEWS

AGRICULTURAL SCIENCE SECTION

Dr. W. K. Stone has been appointed to the newly created position of Professor of Dairy Husbandry in Dairy Manufacturing Research at Virginia Polytechnic Institute. Dr. Stone received his undergraduate degree and his M.S. degree at Utah Agricultural College and his Ph.D. degree at the University of Wisconsin. Prior to coming to Blacksburg he was employed by the Food and Can Institute, U. S. Army Corps, Chicago, Illinois.

Dr. V. L. Baldwin assumed his duties as Associate Professor of Dairy Husbandry and Associate Dairy Husbandman of the Virginia Agricultural Extension Service on February 15. He is a graduate of the University of Minnesota and received his B.S., M.S. and Ph.D. degrees from that institution. Prior to coming to Virginia Polytechnic Institute he was on the staff of the Dairy Department at the University of Minnesota.

The Farm and Home Development phase of the Agricultural Extension program is rapidly getting under way in Virginia. A training school for county Extension workers of 16 pilot counties, two others that may become such, and for specialists was held at Virginia Polytechnic Institute December 13-18. Training schools were also held in the five supervisory districts for white county workers in non-pilot counties. A training school for Negro workers was held at Petersburg February 28-March 2.

In the pilot counties, 19 additional workers have been employed to carry out the activity, with provision for a number of additional ones. The funds provided by the 83rd Congress were intended largely for use on the county level but did provide for some additional personnel on the State level to take care of critical needs. Work in the non-pilot counties will be conducted with only a few families by present county staff members.

This emphasis placed on Farm and Home Development is in recognition of a need to assist farm families to analyze their present economic status and to initiate plans for long range progress.

Mr. L. B. Wilkins has been appointed Associate Professor of Horticulture, effective March 1, 1955, to serve as Extension Vegetable Specialist at Virginia Polytechnic Institute. He will make his headquarters at Blacksburg and will coordinate the activities of the several specialists working in the field of vegetable production. Mr. Wilkins took his college training in Agricultural Economics at Virginia Polytechnic Institute, receiving his B.S. degree in 1933 and his M.S. degree in 1934. He has served as County Agent of Norfolk County for a number of years.

Mr. Edsel L. Phillips has been appointed Associate Professor of Horticulture at Virginia Polytechnic Institute effective March 15, 1955. He will be located at the Piedmont Research Laboratory at Charlottesville, Virginia. Mr. Phillips will serve half time as a Fruit Extension Specialist and give half time to research. He received his B.S. degree in Horticulture from the University of Idaho in 1950. He comes to Virginia after

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having served for several years on the staff of the Mississippi Agricultural Experiment Station.

Mr. Jerry B. Hardigree has been appointed Instructor of Horticulture at Virginia Polytechnic Institute effective January 1, 1955. He will assist with the research work in fruit breeding. Mr. Hardigree received his B.S. degree in Horticulture from the University of Georgia.

Mr. James D. Ashley has been appointed Instructor of Horticulture at Virginia Polytechnic Institute effective March 1, 1955. He will be responsible for producing vegetable and floriculture crops at the greenhouses for use in research and teaching. Mr. Ashley received his B.S. degree in Horticulture at Virginia Polytechnic Institute in June, 1948.

Mr. Andrew J. Lambert has been appointed Associate Extension Agricultural Engineer at Virginia Polytechnic Institute. Mr. Lambert received his B.S. degree in Agricultural Engineering at this institution in 1950. He was formerly employed as Agricultural Engineer by the Appalachian Electric Power Company at Rocky Mount, Virginia.

Dr. Robert A. Barton, Veterinary Field Supervisor, Division of Animal Industry, Department of Agriculture of Virginia, resigned December 15, 1954, to accept a position in the Procurement Department of Kingan and Company at their Richmond Plant. Dr. Barton had nine years' experience as a practicing veterinarian before entering State service in 1950. He is a native of New York and a graduate of the University of Pennsylvania.

Dr. Bryan Baker, Jr. has been appointed Associate Professor of Animal Husbandry at Virginia Polytechnic Institute. His responsibilities will include three-fourths time teaching and a fourth time research. He replaces Robert A. Edgar, who resigned in November to accept a position at the Mississippi Station.

The Animal Husbandry Department of Virginia Polytechnic Institute presented four papers at the Southern Agricultural Workers' Meeting at Louisville, Kentucky: one paper by H. R. Thomas, C. C. Brooks and C. M. Kincaid entitled "BOF Tankage as a Source of Protein Supplement for Swine"; another one by K. C. Williamson, "Factors Influencing Prices Paid for Feeder Calves in Virginia Calf Sales"; and another, "Feeding of Peanut Hulls" by H. R. Thomas and C. M. Kincaid; the fourth paper by Dr. C. M. Kincaid on the "Relationship of Offal to the Weight and Age of Cattle."

The Association of Southern Agricultural Workers met at Louisville, Kentucky on February 7, 8, and 9. R. K. Stivers of Virginia Polytechnic Institute's Agronomy Department presented a paper before the Soils Division of the Agronomy Section. It was entitled "Relation of Subsoiling, Deep Lime and Deep Phosphate Application to the Yields of Corn, Peanuts and Alfalfa in Virginia" by R. K. Stivers, J. H. Lillard, G. D. Jones and A. H. Allison.

The American Society of Agronomy met in Saint Paul, Minnesota November 8-12, 1954. R. K. Stivers presented a paper entitled "The Correlation of Soil Tests with Crop Response in Virginia" by R. K. Stivers, C. I. Rich and R. E. Blaser, Virginia Polytechnic Institute.

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Dr. Walter S. Wilkinson has been appointed Associate Professor of Animal Husbandry and Associate in Biochemistry and Nutrition at Virginia Polytechnic Institute. Dr. Wilkinson secured his Ph.D. degree from the University of Wisconsin. He assumed his duties on January 15, 1955. His responsibilities will include the investigation of the utilization of forages by livestock.

Among the members of the Virginia Polytechnic Institute staff attending the meetings of the Association of Southern Agricultural Workers at Louisville, Kentucky, from the seventh through the ninth of February was Dr. E. P. Johnson, of the Animal Pathology Section, who was a guest speaker at the Poultry Section of the Association on the subject "A Vaccination Program for the Prevention of Avian Respiratory Diseases."

At the same session a paper by Alexander Harris, Clayton E. Holmes, and James H. Bywaters on "The Usefulness of Grit for Broilers" was presented by Dr. Bywaters. Dr. Bywaters was elected Secretary of the Poultry Section for 1956.

—WESLEY P. JUDKINS, *Virginia Polytechnic Institute.*

BIOLOGY SECTION

Hudnall R. Croasdale, a native of Reedville, Virginia, has joined the Virginia Fisheries Laboratory staff at Gloucester Point to assist in the study of migratory finfish. Mr. Croasdale served in the Army from 1952 to March, 1954. He was in the Navy during 1945 and 1946. A graduate of the University of Virginia in 1951, Croasdale had previously attended Virginia Polytechnic Institute. Since his release from the Army he has been engaged in commercial fishing. Mr. Croasdale, his wife, and son are now making their home at Gloucester Point.

Clarence E. Richards, Biologist from Concord, New Hampshire, has joined the Virginia Fisheries Laboratory to assist William H. Massmann and others in determining the causes in the fluctuation of abundance of some of our more important migratory fish. Richards is a recent graduate of the Wildlife Conservation School at Virginia Polytechnic Institute and is a member of the Wildlife Society of America. He graduated from Concord High School in June 1945 and was a member of the Army Air Force from then until 1946. He received his B.S. degree from the University of New Hampshire in 1951, Biology and Forestry being his major subjects.

Mr. William L. Mengebier, formerly professor of biology at the Citadel, has been appointed chairman of the biology department at Madison College. Mr. Mengebier received a B.S. degree from the Citadel, M.S. from Oberlin, and Ph.D. from the University of Tennessee. Mr. Mengebier began his duties at Madison in the fall of 1954.

Longwood College and Madison College announce the inauguration of a graduate program of study. Longwood will offer a course in evolution in the summer session of 1955 with Mr. George W. Jeffers as instructor. Madison offers *Vertebrae Ecology* by Mr. Mengebier and *Major Diseases of Man* by Mr. Shawver for the 1955 summer session.

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The following University of Virginia graduate students are now located at the institutions indicated:

Mr. Robert Amy, Susquehanna University
Mr. John Davis, Washington and Lee University
Miss Harriet Farrier, Department of Neurology and Psychiatry, University of Virginia Medical School
Mr. Donald Foard, Longwood College
Miss Nancy Groseclose, Agnes Scott College
Mr. James Larimer, Duke University
Miss Mary Jo Parrish, Mary Washington College
Miss Jean Pugh, Norfolk Division, College of William and Mary and Virginia Polytechnic Institute

Miss Pollyanna Martin of Lynchburg, a senior at Longwood College, recently became the bride of Mr. Donald E. Foard, research assistant at Longwood. Mr. and Mrs. Foard are living in Farmville.

—ROBERT T. BRUMFIELD, *Longwood College*

ENGINEERING SECTION

Dr. Lawrence R. Quarles, Assistant Dean of the University of Virginia School of Engineering, became a charter member of the American Nuclear Society which was organized in October, 1954.

Mr. Tilton E. Shelburne and Mr. Phillip E. Melville of the Virginia Council of Highway Investigation and Research attended the annual meeting of the Highway Research Board in Washington, D. C. in January, 1955. Mr. Shelburne also attended the meeting of the American Association of State Highway Officials, Highway Transport Committee, where final plans for a highway test road in Illinois were formulated. Mr. Phillip Melville presented a paper, "Concrete Aggregate Reaction in Virginia" at the annual symposium on geology at Johns Hopkins University, Baltimore, Maryland. Mr. Melville also attended a meeting of the American Concrete Institute in Milwaukee, Wisconsin.

Dr. Nelson F. Murphy, Department of Chemical Engineering, Virginia Polytechnic Institute, presented a paper "Mass Transfer in a Horizontal Liquid-Liquid Extraction Tube" at the annual meeting of the American Institute of Chemical Engineers in New York in December, 1954.

Dr. Dale F. Davis, Department of Chemical Engineering, Virginia Polytechnic Institute, recently published papers entitled "Fire Protection in the Paper Industry" in the November issue of *Paper Industry*; "A New Flexibility Test for Rubber," in the December *Rubber Age*; and "Specific Heats of Fluids," in the January issue of *Chemical Engineering*.

Professor Dan H. Pletta of the Department of Applied Mechanics, Virginia Polytechnic Institute, is editor of the *Engineering Mechanics Division Newsletter*, published by the American Society of Civil Engineers.

Professor W. A. Murray of the Electrical Engineering Department, Virginia Polytechnic Institute, was elected second vice-president of the Blacksburg chapter of the American Society of Professional Engineers.

—ROBERT M. HUBBARD, *University of Virginia.*

GEOLOGY SECTION

The Virginia Division of Geology is co-sponsoring with the Appalachian Geological Society and the West Virginia Geological Survey a Spring Field Conference in the Harrisonburg, Virginia, area on May 20, 21, and 22. The conference will be devoted to a study of the older "Paleozoics" and basement complex of the northern Appalachians. All who plan to participate in the conference should indicate their intention by letter to William M. McGill or Robert S. Young, Virginia Division of Geology, Box 3667, University Station, Charlottesville, Virginia, on or before April 15.

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Mr .W. T. Parrott, of the Virginia Department of Highways, reports that the results of a statewide aggregate survey, published as "Physical Test Results of the Virginia Highway Statewide Aggregate Survey," has created a great deal of interest in geological and engineering circles. The booklet is a compilation of tests on more than 2,000 samples of stone and aggregate which were collected over a six-year period. Mr. Parrott also reports a successful meeting of geologists and engineers at the Sixth Annual Symposium on Geology held at Johns Hopkins University on February 18th.

Of much interest to the members of the Geology section is the recent publication "Geology and Oil Resources of the Jonesville District, Lee Co., Virginia" by Ralph L. Miller and William P. Brosge. This report, U. S. G. S. Bull. 990, was prepared in cooperation with the Virginia Geological Survey. The Bulletin may be obtained from the Superintendent of Documents, Washington, 25, D. C.

The Geology Department of Virginia Polytechnic Institute has nearly completed a new thin-sectioning laboratory which includes an automatic feed diamond saw and three laps. C. E. Sears recently demonstrated to members of the Holden Society of Virginia Polytechnic Institute the use of a Ruska magnetometer and also the use of a sun compass. Byron N. Cooper gave a talk on industrial limestones of Virginia at the AIME meeting in Chicago, February 14-17. He also participated in a symposium on carbonate rocks held at the University

of Michigan, February 12. His paper dealt with the origin of Appalachian dolomites.

"Silica Sand Resources of Western Virginia" is the title of a paper which has been issued as Bulletin No. 96 of the Virginia Engineering Experiment Station. The bulletin was prepared by W. D. Lowry.

—W. D. LOWRY, *Virginia Polytechnic Institute.*

STATISTICS SECTION

Dr. Boyd Harshbarger, Head of the Department of Statistics at Virginia Polytechnic Institute, will be teaching Design of Experiments at the Southern Regional Graduate Summer Session which will be held at the University of Florida in Gainesville, Florida.

Dr. R. A. Bradley will return to his position as Professor of Statistics at the Virginia Polytechnic Institute on June 1, 1955. He has been a visiting professor at Rutgers University.

Dr. Robert E. Serfling of the Department of Health, Education, and Welfare presented a paper to a joint seminar of the Biology and Statistics Departments of Virginia Polytechnic Institute. His topic was "The Place of Statistics in Public Health Research."

Dr. P. N. Somerville resigned his position as Associate Professor at Virginia Polytechnic Institute April 1 to accept a position at the American University in Washington, D. C.

Paul C. Cox of White Sands Proving Ground and Robert Richards of the Redstone Arsenal will present seminars during the spring quarter at Virginia Polytechnic Institute.

Dr. W. A. Thompson of the Virginia Polytechnic Institute will publish a paper, "The Ratio of Variances in a Variance Components Model," in the June issue of the *Annals of Mathematical Statistics.*

—LIONEL WEISS, *University of Virginia*

Virginia Academy of Science

Program

OF THE

Thirty-Third Annual Meeting

AT MADISON COLLEGE

HARRISONBURG, VIRGINIA

MAY 11, 12, 13, 14, 1955

Host to Meeting

Madison College

Virginia Academy of Science

OFFICERS

IRVING G. FOSTER, *President*
WALTER S. FLORY, *President-Elect*
E. C. L. MILLER, *Secretary-Treasurer Emeritus*
FOLEY F. SMITH, *Secretary-Treasurer*

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BYRON N. COOPER (1958)
WILLIAM M. HINTON (1959)
HORTON H. HOBBS, JR.
BOYD HARSHBARGER
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PAUL M. PATTERSON (1955)
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WILBERT CHAPPELL, *Meeting Rooms and Equipment*
RAUS HANSON, *Geology Field Trip*
A. M. SHOWALTER, *Biology Field Trip*
S. C. BOCSKEY, *Signs and Maps*
R. D. COOL, *Chemical Industry Tour*
C. P. SHORTS, *Information*
MADISON COLLEGE FACULTY WIVES CLUB, *Entertainment for Ladies*

HOST TO MEETING

MADISON COLLEGE
TYLER MILLER, *President*

General Program of The Thirty-Third Annual Meeting 1955

WEDNESDAY, MAY 11

5:00 P.M. to 10:00 P.M.—Registration for Junior Academy Members, Participants in the Science Talent Search—Foyer, Madison Memorial Library.

5:00 P.M. to 10:00 P.M.—Arranging Exhibits—Burruss Science Hall.

THURSDAY, MAY 18

8:00 A.M. to 5:00 P.M.—Registration for Junior Academy Members, Senior Academy Members and Guests—Foyer, Madison Memorial Library.

9:00 A.M.—Meeting of Science Exhibit Judges, Science Talent Search Judges—Burruss Science Hall, Rooms 201, 209.

9:30 A.M.—Meeting of Chairman and Exhibitors, and Science Talent Search Participants—Burruss Science Hall, Room 109.

10:00 A.M. to 12:30 P.M. and 1:30 P.M. to 4:00 P.M.—Finalists of Talent Search meet with Chairman and Interviewers—Burruss Science Hall, Rooms 2, 7, 307, 308.

10:00 A.M. to 12:30 P.M. and 1:30 P.M. to 4:00 P.M.—Judging of Science Exhibit Contests—Burruss Science Hall .

1:00 P.M. to 2:00 P.M.—Luncheon.

2:00 P.M.—Meeting of the Council of the Academy—Burruss Science Hall, Room 103.

4:00 P.M.—Meeting of all Senior Academy Section Officers—Burruss Science Hall, Room 109.

4:30 P.M.—Meeting of the Section Editors—Burruss Science Hall, Room 209.

5:00 P.M.—Meeting of Virginia Junior Academy of Science Committee—Burruss Science Hall, Room 11.

7:00 P.M.—Business Meeting, Junior Academy of Science—Wilson Hall, Auditorium.

7:30 P.M.—Address of Guest Speaker for Junior Academy Members and Guests—Wilson Hall, Auditorium.

8:30 P.M.—Senior Academy Conference and General Meeting—Wilson Hall, Auditorium.

FRIDAY, MAY 13

8:30 A.M.—Registration.

9:00 A.M.—Section Meetings: (See detailed sectional programs below for exact hour.)

Agricultural Sciences—Wilson Hall—Room 28
Astronomy, Mathematics, Physics—Burruss Science Hall—Room 11
Bacteriology—Burruss Science Hall—Room 311
Biology—Burruss Science Hall—Room 109
Chemistry—Wilson Hall—Auditorium
Education—Wilson Hall—Room 27
Engineering—Burruss Science Hall—Room 201
Geology—Burruss Science Hall—Room 209
Medical Sciences—Wilson Hall—Room 25
Psychology—Wilson Hall—Rooms 21 and 32
Science Teachers—Burruss Science Hall—Room 103
Statistics—Burruss Science Hall—Room 301

10:00 A.M. to 11:30 A.M.—Symposium, "What's New in Chemistry," sponsored by Science Teachers Section—Burruss Science Hall, Room 103.

12:00 noon to 1:00 P.M.—Junior-Senior Scientist Hour *at which awards will be presented*—Wilson Hall, Auditorium.

1:00 P.M. to 2:00 P.M.—Luncheon.

2:00 P.M.—Section Meetings.

4:45 P.M. to 6:00 P.M.—Madison College will be host at a tea to the Members and Guests of the Academy—Alumnae Hall Parlor.

7:45 P.M.—Short Business Meeting, Senior Academy—Wilson Hall, Auditorium.

8:30 P.M.—Address by Mr. Jerome Namias, Chief, Extended Forecast Section. U.S. Weather Bureau—Wilson Hall, Auditorium.

SATURDAY, MAY 14

9:00 A.M.—Section Meetings.

10:00 A.M.—Academy Council Meeting—Burruss Science Hall, Room 103.

Section of Agricultural Sciences

RODNEY C. BERRY, *Chairman*
R. W. ENGEL, *Vice-Chairman*
PAUL M. REAVES, *Secretary*
WESLEY P. JUDKINS, *Section Editor*

FRIDAY, MAY 13, 1955—9:00 A.M.—ROOM 28, WILSON HALL

9:00 Announcements, Committee Appointments, etc.

1. 9:15 Forage-Grain Substitution Rates in Milk Production Considered Further.
Carl W. Allen; *Virginia Agricultural Experiment Station.*

2. 9:30 Soil Factors Affecting the Availability of Manganese for Peanuts.
C. I. Rich; *Virginia Agricultural Experiment Station.*

3. 9:45 Crop Response to Various Rotations in the Peanut-Producing Area of Virginia.
D. L. Hallock and L. I. Miller; *Virginia Agricultural Experiment Station.*

4. 10:00 Seedling Injury in Treated Wheat.
James W. Midyette, Jr.; *Virginia Department of Agriculture.*

5. 10:15 Preliminary Observations on the Value of a Low Calcium-High Phosphorus Diet for the Prevention of Milk Fever in Dairy Cows.
W. A. Hardison, G. A. Miller, R. A. Sandy, and G. C. Graf; *Virginia Agricultural Experiment Station.*

10:30 Recess.

6. 10:45 Crop Response to Rock Phosphate on Virginia Soils.
W. W. Moschler; *Virginia Agricultural Experiment Station.*

7. 11:00 Sulfur Content of the Precipitation in Virginia.
J. A. Lutz, Jr.; *Virginia Agricultural Experiment Station.*

8. 11:15 Progress Report on the Use of V-C 13 for the Control of Nematodes Infesting Turf Grasses.
M. A. Manzelli; *Virginia-Carolina Chemical Corporation.*

9. 11:30 Application of Soil Survey to Certain Land Use Programs in Fairfax County.
H. C. Porter; *Soil Survey, Virginia Agricultural Experiment Station.*

10. 11:45 The Use of Sex Hormones for Fattening Lambs.
W. S. Wilkinson; *Virginia Agricultural Experiment Station.*

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—1:30 P.M.

11. 1:30 Observations on the Physiology of the Bovine Digestive Tract with Special Reference to Organ Activity.
W. E. C. Moore and K. W. King; *Virginia Agricultural Experiment Station.*

12. 1:45 *In Vitro* Estimation of the Cellulolytic Activity of Rumen Ingesta.
S. E. Wood and W. E. C. Moore; *Virginia Agricultural Experiment Station.*

13. 2:00 Freezing Bovine Semen.
Paul M. Reaves, R. B. Potts, and E. A. Drinkwater; *Virginia Polytechnic Institute.*

14. 2:15 Variety, Type, Location and Yearly Effects on the Chemical Composition of Peanuts.
J. F. Eheart, R. W. Young, and Allen H. Allison; *Virginia Agricultural Experiment Station.*

2:30 Recess.

15. 2:45 Factorial Experiments Give Valuable Information on How to Fertilize in Virginia.
R. K. Stivers, P. T. Gish, G. D. Jones, and Boyd Harshbarger; *Virginia Agricultural Experiment Station.*

16. 3:00 Control of the Sting Nematode on Peanuts with an Ethylene Dibromide-Vermiculate Mixture.
Lawrence I. Miller; *Virginia Agricultural Experiment Station.*

17. 3:15 Highly Chlorinated Naphthalene Studies in the Rat and the Calf.
B. E. Joyce, W. B. Bell, and R. W. Engel; *Virginia Agricultural Experiment Station.*

18. 3:30 Growth Hormone Concentration in Swine Pituitaries.
Bryan Baker; *Virginia Agricultural Experiment Station.*

19. 3:45 Changing Concepts in Milk Sanitation.
G. S. Kennedy; *Roanoke Health Department.*

4:00 Business Session.

Section of
Astronomy, Mathematics, and Physics

H. Y. LOH, *Chairman*
J. GORDON STIPE, JR., *Acting Secretary*
F. L. HEREFORD, *Section Editor*

FRIDAY, MAY 13, 1955—10:00 A.M.—ROOM 11
BURRUSS SCIENCE HALL

1. 10:00 Scattering of 200 Kev Electrons in Gold Foils.
   W. G. Pettus, H. G. Blosser, and F. L. Hereford; *University of Virginia.*
2. 10:15 Temperature Effects in the Annihilation of Positrons.
   R. T. Wagner and F. L. Hereford; *University of Virginia.*
3. 10:30 Design of the V. P. I. 1.5 Mev Pressurized Electrostatic Accelerator.
   T. M. Hahn; *Virginia Polytechnic Institute.*
4. 10:45 Two-photon Stokes Parameters.
   Stephen Berko; *University of Virginia.*
5. 11:00 Quenching of the Anomalous Lifetime Component of Positron Annihilation in Organic Compounds by Free Radicals.
   A. J. Zuchelli and S. Berko; *University of Virginia.*
6. 11:15 Positron Annihilation Lifetime in Semiconductors.
   Hugh S. Landes and S. Berko; *University of Virginia.*
7. 11:30 A New Fast Triple Coincidence Circuit Using Secondary Emission Tubes.
   Herbert O. Funsten and S. Berko; *University of Virginia.*

11:45 Business Meeting.

12:00 Noon - 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—2:00 P.M.

8. 2:00 Closed Expressions for Two Trigonometric Series.
   Marvin Stippes; *Virginia Polytechnic Institute.*
9. 2:15 The Stieltjes Integral in n-Dimensional Space.
   E. J. McShane; *University of Virginia.*
10. 2:30 Motions and Distribution of Red Dwarf Stars.
    George Mumford; *University of Virginia.*
11. 2:45 Electrodeless Discharge through Gases at Low Frequencies.
    Paul S. Nekrasov and H. Y. Loh; *Virginia Polytechnic Institute.*

12. 3:00 Reflected Fringes of Multiples-beam Interference.
H. Y. Loh; *Virginia Polytechnic Institute.*

13. 3:15 Diffusion Fields to Growing Crystal Surfaces.
Marvin M. Levine; *University of Virginia.* (Introduced by N. Cabrera.)

14. 3:30 Lattice Relaxations around Lattice Imperfections.
George Hall; *University of Virginia.* (Introduced by N. Cabrera.)

15. 3:45 Surface Energy of Metals.
Robert McIntyre; *University of Virginia.* (Introduced by N. Cabrera.)

16. 4:00 Interference Fringes of Beats Investigated with Superposed Transparencies.
L. G. Hoxton; *University of Virginia.*

17. 4:15 Infra-Red Dispersion in the Region of Absorption Bands.
Melvin A. Pittman; *Madison College.*

Section of Bacteriology

H. J. WELSHIMER, *Chairman*
W. F. LAWRENCE, *Vice-Chairman*
MILES G. BOWLES, *Secretary*
J. DOUGLAS REID, *Section Editor*

SATURDAY, MAY 14, 1955—11:00 A.M.—ROOM 311
NEW SCIENCE BUILDING

11:00 A.M. Business Meeting.

SATURDAY, MAY 14, 1955—1:30 P.M.

1. 1:30 Some Problems in the Simplification of *Endamoeba histolytica* Cultivation Medium.
E. Clifford Nelson and Muriel M. Jones; *Medical College of Virginia.*

2. 1:45 Contamination in Bank Blood.
A. Rosensweig; *McGuire Veterans Hospital,* Richmond.

3. 2:00 Serological Studies of *Lactobacilli.*
P. Arne Hansen and R. H. Miller; *University of Maryland.*

4. 2:15 An Unusual, Small, Gram Positive Rod Isolated From Spinal Fluid.
Herbert J. Welshimer; *Medical College of Virginia.*

5. 2:30 A Comparison of the Original Loewenstein Media with Jensen's Modification of Loewenstein in the Culture of *Mycobacterium tuberculosis.*
William A. Dorsey and Jo Soles; *Department of Public Health,* Richmond.

6. 2:45 Human Tissues in Tissue Cultures.
A. E. Feller; *School of Medicine, University of Virginia.*

7. 3:00 A Study on Some Racial Differences with Respect to Tuberculosis.
Margaret S. Anderson; *Madison College.*

8. 3:15 The Tuberculostatic Activity of Aqueous Extracts Prepared from Selected Mammalian Tissues.
Quentin N. Myrvik; *School of Medicine, University of Virginia.*

Section of Biology

ROSCOE HUGHES, *Chairman*
JACQUES RAPPAPORT, *Vice-Chairman*
JACK D. BURKE, *Secretary*
ROBERT T. BRUMFIELD, *Section Editor* (1957)

FRIDAY, MAY 13, 1955—9:30 A.M.—ROOM 109
BURRUSS SCIENCE HALL

9:30 Announcements—Committee reports.

1. 9:40 The Inheritance of Fruit-shape in *Cucurbita moschata.*
A. M. Showalter; *Madison College.*

2. 10:00 The Development of the Ovule, Megasporogenesis, and Megagametogenesis in *Typha angustifolia.*
Philip E. Graef; *University of Virginia.*

3. 10:10 Certain Bryophytes with Critical Distribution in Virginia.
Paul M. Patterson; *Hollins College.*

4. 10:20 Observations on the Effects of Eyestalk Extirpation on the Female Crayfish, *Cambarus longulus longulus,* Girard.
Elizabeth M. Zipf; *University of Virginia.*

5. 10:30 Growth of Oysters at Gloucester Point, Virginia.
J. L. McHugh; *Virginia Fisheries Laboratory.*

6. 10:40 *Betula uber* (Ashe) Fernald in Smyth County, Virginia.
A. B. Massey and L. R. Hundley; *Virginia Polytechnic Institute.*

7. 10:45 A Tendency Toward Cyclic Dimorphism in Female Crayfishes.
Horton H. Hobbs, Jr.; *University of Virginia.*

10:55 Business Meeting.

12:00 Noon – 1:00 P.M.——Junior-Senior Scientist Hour——Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955——1:30 P.M.

8. 1:30 Liver Restoration in the Golden Hamster After Partial Hepatectomy——Preliminary Report.
William L. Mengebier, Antonina Skapars, Oliver Henderson; *Madison College* and *Texas A. and M. College.*

9. 1:40 A Preliminary Report on Observations of the Effects of Eye-Extirpation on Testicular Behavior in the Crayfish.
Sam R. Telford, Walter H. Lewis, and John B. Kayan; *University of Virginia.*

10. 1:50 The Somatic Chromosomes of *Tulbaghia.*
W. S. Flory, Jr.; *University of Virginia.*

11. 2:00 Alternanthera in Virginia.
A. B. Massey; *Virginia Polytechnic Institute.*

12. 2:05 Chromosome Numbers of Some Species and Hybrids in the Araceae.
Gertrude Earl; *University of Virginia.*

13. 1:15 Water Content of Vertebrate Embryos and Larvae.
A. M. Showalter and Harry Ruebush; *Madison College.*

14. 2:25 Monoecious Tendencies in the Crayfish, *Cambarus longulus longulus,* Girard.
W. H. Lewis; *University of Virginia.*

15. 2:35 Chromosome Complements of Some *Cyrtanthus* Species in Subgenus Monella Compared with that of *C. sanguineus* in Subgenus Gastronema.
W. S. Flory, Jr.; *University of Virginia.*

16. 2:45 Oxygen Capacity Studies in Relation to Body Weight in Albino Rats.
Jack D. Burke; *University of Richmond.*

SATURDAY, MAY 14, 1955—— 9:00 A.M.

Field Trip——Assemble at main entrance of Burruss Science Hall.

Section of Chemistry

J. STANTON PIERCE, *Chairman*
RICHARD M. IRBY, JR., *Secretary*
CARL J. LIKES, *Section Editor*

FRIDAY, MAY 13, 1955—9:00 A.M.—AUDITORIUM, WILSON HALL

9:00 Introductory Remarks by the Chairman.

1. 9:10 The Effects of Various Considerations on the Air Flow through a Cigarette.
P. M. Pedersen and E. S. Harlow; *Richmond.*

2. 9:30 X-Ray Photoelectron Spectrometry.
Ralph G. Steinhardt, Jr.; *Virginia Polytechnic Institute.*

3. 9:55 An X-Ray and Metalographic Study of Large Grain Titanium.
Francis J. Dennis; *Virginia Institute for Scientific Research.*

4. 10:10 Acid and Base Combining Capacity of Zein.
Carl J. Likes and Donald F. Koenig; *Virginia Institute for Scientific Research.*

5. 10:20 Sulfur and Nitrogen Compounds as Antioxidants at Elevated Temperatures.
James W. Cole, Donald R. Campbell, and Robert N. Lawhorn; *University of Virginia.*

6. 10:35 An Improved Smoking Automaton.
Robert C. Lieser and Andrew E. O'Keeffe; *Research Department, Phillip Morris and Company, Ltd., Inc.*

7. 10:50 Electrochemical Preparation of Boron.
Nelson F. Murphy, Richard J. Tinsley and George F. Meenaghan; *Virginia Polytechnic Institute.*

8. 11:05 Systematic Chromatographic Analysis For Metals.
Harriett H. Fillinger; *Hollins College.*

9. 11:15 Guest Lecture—Fundamental Research and the Tobacco Industry.
E. S. Harlow; *Coordinator of Research, Research Laboratory, The American Tobacco Company.*

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—1:50 P.M.

1:50 Business Meeting.

10. 2:00 Determination of Trace Quantities of Nickel in Human Blood.
Maxwell L. Cluett and John H. Yoe; *Pratt Trace Analysis, University of Virginia.*

11. 2:15 Spectrophotometric Determination of Trace Quantities of Magnesium.
Charles K. Mann and John H. Yoe; *Pratt Trace Analysis Laboratory, University of Virginia.*

12. 2:30 Two New Colorimetric Reagents for the Determination of Boron.
Robert L. Grob and John H. Yoe; *Pratt Trace Analysis Laboratory, University of Virginia.*

13. 2:45 An Apparatus for the Study of Ignition and Mass Transfer of Droplet Vapor Systems.
W. E. Rice and S. S. Stein; *Experiment Incorporated.*

14. 3:00 The Experimental Determination of Burning Velocity by the Bunsen Burner Technique.
George J. Gibbs and Hartwell F. Calcote; *Experiment Incorporated.*

15. 3:15 Studies of Ionization in Flames by Means of Langmuir Probes.
I. R. King and Hartwell F. Calcote; *Experiment Incorporated.*

16. 3:30 A New Technique for Studying Dust Explosions.
Lloyd E. Line, Jr. and Wendall J. Clark.

17. 3:45 Some Reactions of Butadiene Cyclic Sulfone.
Robert C. Krug and George R. Tichelaar; *Virginia Polytechnic Institute.*

18. 4:00 Halogenated Isoprenic Cyclic Sulfones.
Robert C. Krug and Teh-Fu Yen; *Virginia Polytechnic Institute.*

19. 4:15 Chromatographic Separation of a Complex Polynuclear Hydrocarbon Mixture.
Frank A. Vingiello and Alexej B. Borkovec; *Virginia Polytechnic Institute.*

20. 4:35 Some Macrocyclic Chemistry.
Albert W. Lutz; *William and Mary.*

21. 4:45 A Submerged Combustion Boiler.
Gerald Golub; *Experiment Incorporated.*

SATURDAY, MAY 14, 1955—9:00 A.M.

AUDITORIUM, WILSON HALL

1. 9:00 Thermodynamics of Complex Ion Formation.
   Loren G. Hepler; *University of Virginia.*
2. 9:15 The Study of Films on Catalytic Surfaces With the Aid of Elliptically Polarized Light.
   Robert E. Cunningham and Fred W. Young, Jr.; *University of Virginia.*
3. 9:25 The Rates of Oxidation of Several Faces of Copper With the Aid of Elliptically Polarized Light.
   F. W. Young; *University of Virginia.*
4. 9:55 Studies of the Coordination of 1,3-bis-(tris-(hydroxymethyl))—methylamino—2—propanol With Some Cations of the First Transition Series.
   Velta Erdmanis and William E. Trout, Jr.; *University of Richmond.*
5. 10:10 A Further Study of Fe (III) and 1,3-bis-(tris-(hydroxymethyl))-methylamino-2-propanol.
   Jane Bell Gladding and William E. Trout, Jr.; *University of Richmond.*
6. 10:25 The Oxidative Determination of Humectant Additives in Tobacco.
   H. E. Wright, Jr. and W. W. Burton; *Research Laboratory, The American Tobacco Company.*
7. 10:40 Comparisons of Zein Textile. Fibers with Fine Clothing Wool.
   George L. Walker; *Research Department, Virginia Carolina Chemical Corporation.*
8. 10:55 Synthesis and Chemistry of O — 2, 4 — Dichlorophenyl O, O — Diethyl Phosphorothioate ("V-C 13 Nemacide) and Its Analogs.
   Charles L. Harowitz; *Research Department, Virginia Carolina Chemical Corporation.*
9. 11:10 The Determination of Residues of O — 2, 4 Dichlorophenyl O, O — Diethyl Phosophorothioate ("V-C 13 Nemacide).
   George R. Boyd; *Research Department Virginia-Carolina Chemical Corporation.*
10. 11:25 Preparation of Some New Aromatic Ketones.
    Frank A. Vingiello and J. Robert Thornton; *Virginia Polytechnic Institute.*
11. 11:35 The Preparation of Some Methyl — and Trichloromethyl-O-benzylphenylcarbinols.
    Frank A. Vingiello and Peter E. Newallis; *Virginia Polytechnic Institute.*

12. 11:45 Trityl Ethers of Negatively Substituted Alcohols.
J. S. Belew, J. O. Edwards, (*Brown University*) and R. Layton; *University of Virginia.*

Section of Education

JACK H. BOGER, *Chairman*
DEFOREST L. STRUNK, II, *Secretary*
JAMES PATTON, *Section Editor*

FRIDAY, MAY 13, 1955—9:00 A.M.—ROOM 27, WILSON HALL

1. 9:00 An Application of the Informal Reading Inventory.
Katherine Minor Anthony; *Madison College.*
2. 9:20 The New Science.
Winfred P. Elson; *Calverton, Virginia.*
3. 9:40 The Prediction of Achievement in High School Biology.
Alonzo M. Myster and Emily Murdock; *Statistical Laboratory, Virginia State College.*
4. 10:00 Comparison of Individual and Small Group Method of Laboratory Instruction in General College Chemistry.
W. Donald Clague; *Bridgewater College.*
5. 10:20 A Project in the Cooperative Production of Instructional Guides for Teachers of Science.
John B. Chase; *University of Virginia.*
6. 10:50 A Study in the Cooperative Improvement of the Quality of Educational Experiences in the Laboratory School of Longwood College.
Helen R. McDowell; *Longwood College.*
7. 11:20 An Analysis of the True Value Factor in the Formula for the Calculation of the Distribution Monies from the Minimum Educational Program Fund and the Salary Equalization Fund of the Virginia State Department of Education with Particular Reference to Northampton County.
Paul G. Watson; *Cape Charles High School.*
8. 11:50 A Preliminary Investigation in the Teaching of College Biology.
Mary H. Richardson; *Stratford College.*

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—1:45 P.M.

9. 1:45 The Construction of a Scale for the Measurement of Attitudes Towards Science in the Elementary Schools and Towards Mathematics in the Junior High Schools.
Alonzo M. Myster, Lillian Banks, and Doris M. Wood; *Statistical Laboratory, Virginia State College.*

10. 2:15 Panel Discussion of "The Manpower Shortage in the Scientific Fields and the Implications for Science Education in the Public Schools".
Panel Members: Jack H. Boger, *Richmond Public Schools*; J. W. Cole, *University of Virginia*; Alfred Wingo, Supervisor of Research, *State Department of Education*, and Alex Sadle, *Allied Chemical and Dye Corporation, Hopewell.*

3:15 Business Meeting.

Section of Engineering

PHILLIP L. MELVILLE, *Chairman*
DUDLEY TOMPSON, *Secretary*
ROBERT M. HUBBARD, *Section Editor* (1958)

FRIDAY, MAY 13, 1955—9:00 A.M.—ROOM 201
BURRUSS SCIENCE HALL

9:00 Opening Remarks—P. L. Melville, *Chairman.*

1. 9:15 Investigation of Slotted and Perforated Transonic Nozzles.
R. W. Truitt and Arthur C. Bruce; *Virginia Polytechnic Institute.*

2. 9:35 A New Method of Accident Analysis and Its Application to Highway Engineering.
Alfred Vick, III; *Virginia Department of Highways.*

3. 10.00 Let's Take the "Burgers" out of Control Systems.
B. A. Niemeier; *Consulting Engineer, Richmond.*

4. 10:25 Model Studies of Prestressed Concrete Beams Used in the Hampton Roads Approach Bridges.
Ignacio Romero; *Virginia Council of Highway Investigation and Research.*

5. 10:50 A Study of Highway Sign Legibility.
Terrence M. Allen; *Virginia Council of Highway Investigation and Research.*

6. 11:15 Schlieren Photography, High Brilliance Light Source.
Orville R. Harris; *University of Virginia.*

7. 11:35 Theory of Free Streamlines in Compressible Flow.
Robert W. Truitt; *Virginia Polytechnic Institute.*

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—1:30 P.M.

8. 1:30 A Study of Variables Affecting Chemical Control of Shrubs on Power Line Right-of-Ways in Southwest Virginia.
Herbert P. Olson and Frank C. Vilbrandt; *Virginia Polytechnic Institute.*

9. 1:50 Calculations of Individual, Mass-Transfer Coefficients for Two-Phase, Liquid Extraction Systems.
John E. Lastovica and Nelson F. Murphy; *Virginia Polytechnic Institute.*

10. 2:10 Characteristics of Sieve Plates for Contacting Liquid and Vapor.
James I. Lankford; *University of Virginia.*

11. 2:30 Individual Dynode Voltage Regulator for Photomultiplier Tubes.
B. d'E. Flagge and O. R. Harris; *University of Virginia.*

12. 2:50 Causes of Highway Sign Failure.
Arthur L. Straub; *Virginia Council of Highway Investigation and Research.*

13. 3:10 An Investigation of the Properties of Various Gradations Meeting F-1, Sand-Asphalt, Specifications.
P. E. McIntyre; *Virginia Council of Highway Investigation and Research.*

14. 3:30 Design and Construction of an Ultrasonic System for Study of Liquid-Liquid Extraction.
Hughey Allen Woodle, Jr. and Dudley Thompson; *Virginia Polytechnic Institute.*

15. 3:50 Use of Prestressed Concrete in the Hampton Roads Bridge Tunnel Project.
J. N. Clary; *Virginia Department of Highways.*

4:10 Junior Academy Awards.

4:40 Business Session.

SATURDAY, MAY 14, 1955—9:30 R.M.—ROOM 201
BURRUSS SCIENCE HALL

16. 9:30 A Study of Bond between Pretension Steel and Concrete in Prestressed Concrete.
Charles E. Echols; *Virginia Council of Highway Investigation and Research.*

17. 9:50 An Analytical Method for Analyzing Hipped Plate Structures.
Daniel Frederick, *Virginia Polytechnic Institute.*

18. 10:10 Atomic Explosion and Structural Stability.
Henry L. Kinnier; *University of Virginia.*

19. 10:20 An Investigation of Wedges at Angle of Attack.
R. W. Truitt and Robert D. Jones; *Virginia Polytechnic Institute.*

20. 10:40 A Semi-Instantaneous Rainfall Ratemeter.
Leo F. Goeller; *University of Virginia.*

21. 11:00 The Design of a Pilot Plant for the Production of Maleic Acid Hydrazide.
Willard Hall Sawyer and Frank C. Vilbrandt; *Virginia Polytechnic Institute.*

22. 11:20 Correlation of Soil Properties and Index Constants.
C. Page Fisher, *Consulting Engineer, Richmond,* and William H. Vogelsang, *Chief Geologist, Froehling and Robertson, Inc., Richmond.*

Section of Geology

WILLIAM T. HARNSBERGER, *Chairman*
WILLIAM T. PARROTT, *Vice-Chairman*
MARCELLUS H. STOW, *Secretary*
W. D. LOWRY, *Section Editor* (1958)

FRIDAY, MAY 13, 1955—9:00 A.M.—ROOM 209,
BURRUSS SCIENCE HALL

(Time for discussion will be allowed at end of each paper.)

1. 9:00 Title to be announced.
Marcellus H. Stow; *Washington and Lee University.*

2. 9:10 Effect of Traffic Polishing on Limestone Aggregates.
William T. Parrott; *Virginia Department of Highways*

3. 9:25 The Bergton-Crab Run Gas Field, Western Rockingham County, Virginia.
R. S. Young and W. T. Harnsberger; *Division of Geology, Virginia Department of Conservation and Development.* (Presented by W. T. Harnsberger.)

4. 9:35 Monazite Deposits of Virginia.
Charles E. Sears, Jr.; *Virginia Polytechnic Institute.*

5. 9:50 Current Manganese Operations in Virginia.
E. O. Gooch; Division of Geology, *Virginia Department of Conservation and Development.*

6. 10:05 Origin of a Greenstone Conglomerate in the Charlottesville Vicinity.
Robert M. Cordova; *University of Virginia.*

7. 10:20 A Peridotite Dike Near Front Royal, Virginia.
Robert S. Young and Roy A. Bailey; *Division of Geology, Virginia Department of Conservation and Development.* (Presented by Robert S. Young).

8. 10:35 Geology of Southeastern Piedmont Virginia.
A. A. Pegau and W. B. Brent; *Division of Geology, Virginia Department of Conservation and Development.* (Presented by A. A. Pegau).

9. 10:45 Are the Depressions of Major Synclines in the Valley and Ridge Province of Virginia of Depositional Origin?
W. D. Lowry; *Virginia Polytechnic Institute.*

11:00 Announcements.

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour— Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—2:00 P.M.

(Time for discussion will be allowed at end of each paper)

10. 2:00 Is the Rockfish Conglomerate Intraformational?
R. V. Dietrich; *Virginia Polytechnic Institute.*

11. 2:15 Ground Water in the Waynesboro Area, Virginia.
Jack Lowden; *University of Virginia.*

12. 2:25 Preliminary Investigation of Fossils in the Arvonia Slate.
Shelton P. Applegate; *University of Virginia.*

13. 2:35 Natural Chimneys of Augusta County, Virginia.
C. C. Fisher; *Division of Geology, Virginia Department of Conservation and Development.*

14. 2:50 Heavy Mineral Correlation in Coastal Plain Sediments.
Allen Sinnott, *U. S. Geological Survey.*

15. 2:55 Mineralogical Studies of Sediments from the Eastern Shore Peninsula of Virginia.
Basil Doerhoefer, III, Thomas B. Neblett, Jr., Harold E. Sturgill, Robert S. Wood; *Washington and Lee University.* (Presented by Robert S. Wood.)

16. 3:05 Mineralogical Studies of Sediments from New River, Virginia.
Charles A. MacIntosh, Alan R. Mixson, David K. Willard, Jr.; *Washington and Lee University.* (Presented by David K. Willard, Jr.)

17. 3:15 Mineralogical Studies of Sediments from Banister River, Virginia.
Sam Berry, Douglas D. Monroe, Leroy H. Simkins, Jr.; *Washington and Lee University.* (Presented by Leroy H. Simkins, Jr.)

18. 3:25 Proposed New Systems of Soil Classification.
G. H. Robinson and S. S. Obenshain; *U. S. Department of Agriculture and Virginia Polytechnic Institute.*

19. 3:35 Soil-Rock Relationships in Fairfax County, Virginia.
J. F. Derting and H. C. Porter; *Virginia Agricultural Experiment Station.* (Presented by J. F. Derting.)

3:45 Business Meeting.

SATURDAY, MAY 14, 1955 — 8:30 A.M.

8:30 Field Trip: Lower and Middle Ordovician Stratigraphy, Middletown Quarry, M. J. Grove Lime Quarry and Mine.
Leaders: C. E. Bass, B. N. Cooper, R. S. Edmundson, Paul Herbert, Robert S. Young.

(Place of assembling and details of trip to be announced during Friday meeting.)

Section of Medical Sciences

SIDNEY SOLOMON, *Chairman*
GROVER C. PITTS, *Secretary*
EBBE C. HOFF, *Section Editor*

FRIDAY, MAY 13, 1955—10:00 A.M.—ROOM 25, WILSON HALL

1. 10:00 A Histochemical Study of Ribose Nucleic Acid in the Eye of the Chick Embryo.
Morris S. McKeehan; *University of Virginia School of Medicine.*

2. 10:15 The Combination of Insulin with Frog Skeletal Muscle.
D. R. H. Gourley; *University of Virginia School of Medicine.*

3. 10:30 Studies on the Activity of the Detrusor Muscle with Special Reference to the Effects of Electrical Stimulation of Forebrain Structures.
Everett H. Ingersoll, Louise L. Jones, and Erling S. Hegre; *Medical College of Virginia.*

4. 10:45 Serum Protein Patterns in Rabbits During Sensitization and Desensitization.
Oscar Swineford, Cornelia Hoch-Ligeti, and Karen Irvine; *University of Virginia School of Medicine.*

5. 11:00 Motion Pictures of Cellular Changes in Tissues of Tadpoles After X-ray Irradiation as Recorded *in vivo.*
Carl Caskey Speidel; *University of Virginia School of Medicine.*

6. 11:15 Further Studies on the Inhibition of Porphyrin Synthesis by Benzimidazole Derivatives.
Lynn D. Abbott, Jr. and Mary J. Dodson; *Medical College of Virginia.*

11:30 Business meeting.

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

7. 1:30 Studies by Paper Electrophoresis of Serum Lipoproteins.
J. C. Forbes and P. C. Taylor; *Medical College of Virginia.*

8. 1:45 The Ultraviolet Absorption Spectra of Iodinated Proteins.
Chalmers L. Gemmill; *University of Virginia School of Medicine.*

9. 2:00 Studies on Metabolites of Nicotine.
Fletcher B. Owen and P. S. Larson; *Medical College of Virginia.*

10. 2:15 A Study of Defecation in the Cat.
Roy L. Mundy and Eugene D. Brand; *University of Virginia School of Medicine.*

11. 2:30 Autonomic Effects of a New Series of Substituted Amines and Quaternary Ammonium Compounds.
W. H. Pindell, J. K. Finnegan, and J. D. Smith; *Medical College of Virginia.*

12. 2:45 The Mechanism of Nitrogen Mustard-Induced Emesis in the Cat.
Eugene D. Brand; *University of Virginia School of Medicine.*

Section of Psychology

GILBERT J. RICH, *Chairman*
AUDREY M. SHUEY, *Secretary-Treasurer*
HENRY M. IMUS, *Executive Committeeman*
R. H. HENNEMAN, *Section Editor*

FRIDAY, MAY 13, 1955—9:30 A.M.—WILSON HALL

9:30-12:00 Noon

Program A—Room 21

Program B—Room 32

12:00 Noon – 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

1:30- 3:00 P.M.

Symposium A—Room 21

Training Programs for Psychologists in Virginia: Present Status and Future Plans

Symposium B—Room 32

The Role and Contributions of Clinical and Counselling Psychologists.

3:00- 5:00 P.M.

Business Meeting (including report of Committee on Evaluation of Functions.)

PROGRAM A—ROOM 21, WILSON HALL

1. 9:00 Factors Determining the Proficiency of Multiple Task Performance.
   Glenn R. Hawkes; *University of Virginia.*
2. 9:20 Vibrotactile Communication and Training.
   William C. Howell; *University of Virginia.*
3. 9:40 The Influence of Varying Probabilities of Reinforcement in a Matching-to-Sample Situation with Humans.
   William E. Montague; *University of Virginia.*
4. 10:00 An Investigation of the Stimulus Dimensions in Vibratory "Phi".
   William H. Sumby; *University of Virginia.*
5. 10:20 Stereotypes and Perceptual Distortion.
   Linda Johnson; *Mary Washington College.*

6. 10:40 The Effect of Stimulus Reversal on Discrimination Chaining.
Milton H. Hodge; *University of Virginia.*

7. 11:00 Visual Recognition Thresholds as Indices of Word Probabilities.
William A. Lee; *University of Virginia.*

8. 11:20 The Retention of Responses to Specific Verbal Stimuli Compared with Retention of Responses to Classes of Verbal Stimuli.
Kenneth E. Lloyd; *University of Virginia.*

PROGRAM B—ROOM 32, WILSON HALL

1. 9:00 Criteria for Enrolling College Students in "Improvement of Reading Skills" Course.
Frances Dean Scott; *Lynchburg College.*

2. 9:20 The Effects of Remedial Reading Upon California Mental Maturity Retest Scores.
William P. Matthews; *Lynchburg College.*

3. 9:40 Disproportionate Contribution of Revised Beta Scales Scores to Total Scores in Adolescent Groups.
Walter A. Woods and Robert Toal; *Richmond Professional Institute.*

4. 10:00 Intelligence Differences in Delinquents as Appraised by Four Psychological Tests.
Walter A. Woods and John A. Farley; *Richmond Professional Institute.*

5. 10:20 Research Programs in Neurological Disease and Blindness.
Henry A. Imus; *National Institute of Health.*

6. 10:40 The Measurement of Primary Mental Abilities by the Columbia Mental Maturity Scale.
Jack H. Boger, Cyril R. Mill, and Charles J. Turner; *Richmond Public Schools.*

7. 11:00 Recent Research in Perception and Its Implications for Research with Projective Techniques.
A. W. Jeffreys, Jr.; *Western State Hospital.*

8. 11:20 A Validity Study of the Morgan Test of Logical Reasoning in Terms of Career Employees for Government Service.
William J. Morgan; *Aptitude Associates, Inc.*

9. 11:40 To Search for Evidence on the Popular Belief that Males Are More Logical in Their Reasoning Processes than Females.
Antonia Bell Morgan; *Aptitude Associates, Inc.*

Section of Science Teachers

G. L. THOMASSON, *Chairman*
FRANKLIN D. KIZER, *Chairman-Elect*
MARTHA W. DUKE, *Secretary*
CAROLINE GAMBRILL, *Section-Editor*

FRIDAY, MAY 13, 1955—9:30 A.M.—ROOM 103
BURRUSS SCIENCE HALL

THEME—*"What's New in Chemistry"*

9:30 Appointment of Nominating Committee.
1. 9:40 Biophysics.
Sidney S. Negus; *Medical College of Virginia.*
2. 10:10 Fibers and Fertilizers.
W. T. Boyer; *Virginia-Carolina Corporation.*
3. 10:40 Medical Chemistry.
Speaker to be announced.
4. 11:10 Trend in Science Teacher Supply.
M. C. Shawver; *Madison College.*
11:40 Report of Nominating Committee.
11:50 Adjournment.
12:00 Noon-1:00 P.M. — Junior-Senior Scientist Hour — Wilson Hall Auditorium.

Section of Statistics

M. C. K. TWEEDIE, *Chairman*
C. Y. KRAMER, *Secretary*
LIONEL WEISS, *Section Editor*

FRIDAY, MAY 13, 1955—9:00 A.M.—ROOM 301

9:00 Introductory Remarks of the Acting Chairman.
1. 9:10 Some Results on Recurrent Event Theory.
John E. Freund; *Virginia Polytechnic Institute.*
2. 9:30 A Property of the Balanced Incomplete Block Designs.
W. A. Thompson, Jr.; *Virginia Polytechnic Institute.*
3. 9:50 On Parameter Estimates Expressed as Sets of Values.
M. C. K. Tweedie; *Virginia Polytechnic Institute.*

4. 10:10 On the Numeration of Consistent Pairwise Comparisons.
R. L. Wine and John E. Freund; *Virginia Polytechnic Institue.*
5. 10:30 Intermission.
6. 10:40 Various Approaches in Evaluating Census Data.
G. W. Suter; *Virginia Cooperative Crop Reporting Service.*
7. 11:00 Some Antecedents of Modern Experiment Design.
Churchill Eisenhart; *National Bureau of Standards.*

12:00 Noon — 1:00 P.M.—Junior-Senior Scientist Hour—Wilson Hall Auditorium.

FRIDAY, MAY 13, 1955—2:00 P.M.

8. 2:00 Business Meeting.
9. 2:30 Estimation of Aircraft Spare Parts Requirements.
Walter Jacobs; *Department of the Air Force.*
10. 2:50 A Statistician Looks at the Employee Security Problem.
Morris J. Solomon; *Bureau of the Census.*
11. 3:30 Intermission.
12. 3:40 Life Testing in the Discrete Case.
F. S. McFeely; *Virginia Polytechnic Institute.*
13. 4:00 New Developments in Paired Comparisons.
R. A. Bradley; *Virginia Polytechnic Institute.*
14. 4:20 Consistency of Subjective Scores in Non-Replicated Experiments.
T. S. Russell; *Virginia Polytechnic Institute.*

SATURDAY, MAY 14, 1955—9:00 A.M.—ROOM 301
BURRUSS SCIENCE HALL

15. 9:00 Some Properties of Order Statistics from Discrete Uniform Distributions.
E. L. Bombara; *Virginia Polytechnic Institute.*
16. 9:20 Sequential Procedures that Control the Individual Probabilities of Coming to the Various Decisions.
Lionel Weiss; *University of Virginia.*
17. 9:40 Some Aspects of Quality Control.
Donald J. Shaw; *E. I. duPont DeNmours and Company.*
18. 10:10 Intuitive Probability and Economic Behavior.
Cleon Harrell; *University of North Carolina.*
19. 10:30 Intermission.

20. 10:40 A Result on Geary's Extension of Berkson's Case of Functional Relationships.
H. C. Sweeny; *Virginia Polytechnic Institute.*

21. 11:00 Designs for Interblock Analysis.
C. C. Beazley; *Virginia Polytechnic Institute.*

22. 11:20 A Study of the Use of an Auxiliary Variate in Analysing Discrete Data.
R. J. Taylor and M. C. K. Tweedie; *Virginia Polytechnic Institute.*

23. 11:40 A Test of Consistency and Inconsistency in Subjective Ratings. (By Title)
A. N. Pozner; *Virginia Polytechnic Institute.*